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AUTHOR Hodes, Carol L.
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ABSTRACT

Two instructional variables, visual illustrations and visual mental imagery, were compared for their influences on learning and cognitive strategies. It was hypothesized, based on dual-code theory, that attempts to combine the two would facilitate learning. In a completely randomized factorial design, treatments consisted of 4 versions of a text-based 2,000-word module on the structure and function of the human heart. Subjects were 112 undergraduates without knowledge in the content area. For the imagery instructed groups, imagery instructions were placed in the treatment booklets in association with the visual illustrations. Results reinforce the importance of relevant visuals to learning and the prominence of imagery use during accretion and retrieval. Main effects were largely produced by visual illustrations, but those who used imagery heavily had higher test scores and were more likely to use imagery in other learning situations compared to those who did not use imagery heavily. Results provide evidence that imagery instructions are valuable for increasing learner interactions with instructional materials, and that they may be especially important when spatial information must be learned. (Contains 28 references.) (SLD)

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The Effect of Visual Mental Imagery on Speed and Accuracy of Information Retrieval

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by
Carol L. Hodes

Instructional design is a field of study which focuses on the impact of instructional variables. The goal of this study was to compare two instructional variables and learn more about their influence on learning and cognitive strategies.

The instructional variables in this study (Hodes 1990, 1992) were visual illustrations and visual mental imagery. Visual illustrations are a heavily studied area and have been shown to help learners isolate and identify important material, recall prior knowledge, provide interaction with content, and enhance information acquisition (Dwyer et al., 1988; Winn et al., 1991).

On the other hand, visual mental imagery is a prominent cognitive process, however it is thought to be under used for learning and is not well researched as an instructional variable. Several studies that try to have subjects use mental imagery are documented (Anderson & Kulhavy, 1972; Kulhavy & Swenson, 1975; Gagne, 1985; Weinstein & Mayer, 1986).

The dual-code theory supports the use of imagery as an instructional variable. According to this theory, learning improves when mental images are formed during accretion because imaged material has two codes, both verbal and non-verbal, in memory. Also, dual-code research has shown that familiar, unambiguous visual illustrations summarize important information and maximize the availability of both verbal and non-verbal cognitive processes, thus promoting dual-coding (Paivio 1969, 1972). Therefore, attempts to combine visual illustrations and visual mental imagery would facilitate learning.

Method

In a completely randomized factorial design, the treatments consisted of four versions of a text-based 2000-word module on the structure and function of the human heart. This module had available three criterion-referenced multiple choice posttests which have been validated for specific types of learning (Dwyer, 1978).

A total of 112 undergraduates participated. To ensure that the subjects were novices in the content area of the study, students with extensive prior knowledge of heart function, i.e., pre-med or physiology majors, were excluded. Subjects were randomly assigned to groups.

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Independent Variables and Treatment Groups

The four treatment groups of 28 subjects each, dealt with instructional text about the human heart, with related visual illustrations and instructions to form visual mental images. The text-only group was group T; the text plus visual illustrations group was group TV; the text plus imagery instructions group was group TI; and the text plus both imagery instructional and visual illustrations was group TVI.

Visual Illustrations. The treatment booklets and related visuals were based on those used previously by Lamberski (1980). The visual illustrations were clear, unambiguous line drawings containing verbal labels on the structures, which is a type shown by Dwyer (1978) to facilitate learning in a cost-effective manner.
Imagery Instructions. Based on Kulhavy and Swenson (1975), imagery instructions were placed on each page of the treatment booklets for the instructed groups. The method described by Dwyer (1978) for the placement of visuals in text was followed in order to correctly derive the instructions to form visual mental images. The treatment without visuals (control) was given to 19 subjects as a pilot study. An item analysis (Gronlund, 1985) of their posttest results formed a guideline for the design of specific instructions to form images. Items with an item difficulty index of less than 60 percent were included in the formation of the instructions. The appropriate imagery instructions were then inserted on each page of the booklets for the imagery treatments. Shepard and Podgarny (1978) and Bransford et al. (1982) state that specific instructions help ensure better internalization and, thus, better posttest results. Also, placing the instructions on each page was rooted in the need to maintain imagery throughout the treatment. Such a technique was used with general imagery instructions by Kulhavy and Swenson (1975).

Dependent Variables

The three criterion-referenced multiple-choice posttests (recognition task) each containing 20 questions are terminology, identification, and comprehension. The terminology test measures knowledge of basic facts and definitions as presented in the text. The identification test is a recognition test that provides visual cues (a heart diagram with numbered arrows) for naming and discriminating heart structures. The comprehension test measures the subject's understanding of the heart's function and requires the subjects to generate concrete visual images in order to locate and position "parts of the heart in their mind's eye" and "mentally simulate functions and movements of the various parts of the heart"...(Dwyer, 1978, pp. 46-47) as this information is retrieved. The following average KR-20 reliability coefficients for each criterion test have been reported by Dwyer (1978): 0.83, terminology; 0.81, identification; 0.77 comprehension, and 0.92 total criterion test (p. 47).

The drawing test (the recall task) was a page with a list of twenty structures described in the text. Each structure had to be included on the drawing. A point was given for each correctly placed structure on the drawing. A Kuder-Richardson reliability coefficient of 0.839 was calculated for this test.

Drawing is related to the generation of mental images. Such a task requires the subjects to generate an image in the visual buffer of short term memory

before they can correctly reproduce the anatomical structures and symbols with respect to each other. This is the visual-to-motor translation process described by Farah (1984) in her extension of Kosslyn's (1980) imagery model.

Imagery instructions may cause subjects to attend to details of structural information resulting in the formation of a more complete mental representation. If there is a more complete mental representation due to the orienting quality of the imagery instructions and the increased attention to structural details, it should be evident when a constructional task is used as a criterion measure, such as drawing a complex object as described in text. The quality of the drawings was not a factor in the scoring. The scoring was based on correct placement of the structures.

A measure of time was also recorded to the nearest second by the subjects for both accretion (the reading portion of the treatments) and the testing portion. Theoretically, those receiving the imagery instructions should require more time to complete the reading task if imagery was induced during accretion (Kosslyn et al., 1984). If imagery was used extensively during the post testing, the subjects should also require more time.

A post-treatment questionnaire was also used to assess the subjects' perceptions of their use of imagery during the experiment. This questionnaire used a Likert scale and comprised four items which addressed the subjects' use of imagery and other learning strategies. The first item, for example, asked the subjects if they "formed pictures in their mind" during the task they had just completed. The remainder of the questions collected a profile of the subjects' imagery, or mental "picture," use during formal learning and other situations, and asked the subjects to rate the accuracy of their images. A fifth item was a multiple-choice item which inquired about the subjects' dominant learning strategy during the treatment.

Results

ANOVA tests were used on all dependent measures. An alpha of 0.05 was used for all statistical tests. Using an alpha of 0.05, the critical value of F for 1 and 108 degrees of freedom is 3.92.

Achievement with Visuals versus Imagery

The ANOVA of the scores of the combined tests revealed a significant main effect for the visual illustration factor ($F=5.32$, $p=0.02$). When looking at the individual posttests, the visual illustrations also produced a significant main effect in the identification test (TV mean = 13.79, T mean = 12.54, F (visuals) = 12.05, $p=0.001$). The identification test is a type of visual test, since a diagram is used to identify parts when answering questions. Also, group TVI had the highest mean on the identification test (14.43), while the TI group's mean was the lowest (10.61), a pattern that was seen throughout the multiple-choice test scores. Thus, although specific imagery instructions might be effective for learning, they cannot replace the function of visual illustrations for learning and recognition tasks. In fact the group TVI mean on the identification test indicated that a moderate interaction (p. 0.08) had occurred between the visuals and the imagery instructions.

Drawing Test

Analysis of variance on the drawing posttest (recall task) revealed that group

TI's mean was significantly higher than the mean of group T, the control group ($F=4.79$, $df=1/108$, $p < 0.05$). The mean of group TV was also significantly higher than group T ($F=37.71$, $df=1/108$, $p < 0.00$). Therefore the more effective variable for a constructional task is visual illustrations. Samples of the drawing test from group TI (an "instructed" subjects) and group T (an "uninstructed" subject are shown in figures 1 and 2.

Significant positive correlations were also found between the drawing test scores and more accretion time ($r=0.267$, $p <0.01$), and the drawing test scores and the use of imagery during accretion ($r=0.253$, $p<0.05$). In addition, subjects with the highest multiple-choice test scores were more likely to use imagery heavily during accretion ($r=0.258$, $p<0.01$). Thus, the use of mental imagery may increase interactions with the instructional material which requires more time, as well as improve performance on both multiple-choice (recognition) and constructional tasks.

Patterns of Imagery Use

The five items that inquired about the use of imagery as a strategy were the basis for the correlations and observations about the subjects' perceived imagery use during the experimental task, for other learning tasks, and during other tasks. Subjects with higher task use of imagery required less time to complete the multiple-choice tests ($r=-0.228$, $p< 0.05$), and claimed to use imagery more heavily during other learning tasks ($r=0.473$, $p<0.01$).

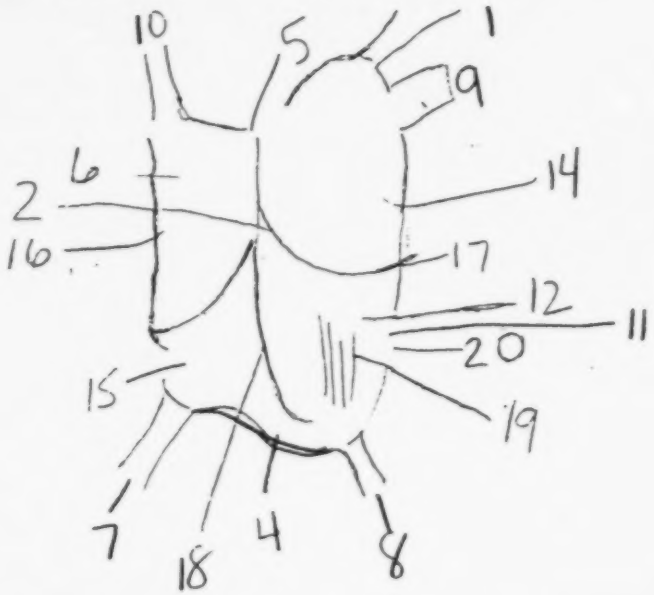
Subjects who felt that they formed accurate mental images were more likely to report higher task use of imagery ($r=0.404$, $p<0.01$) and were more likely to use imagery during other learning tasks ($r=0.429$, $p<0.01$).

Discussion and Conclusions

The results of the present study reinforce the importance of relevant visuals to learning as summarized by Dwyer (1978), Dwyer et al. (1988), and Winn (1989), and the prominence of imagery use during accretion and retrieval. The analysis of the multiple-choice (recognition) posttests showed that the main effects were largely produced by the presence of the visual illustrations. However, for the drawing (recall) test, it was the imagery factor that produced the significant results although it was not the dominant strategy used by this group (TI) during accretion. A moderate but nonsignificant interaction was also noted between the visuals and imagery on the identification test, which used a diagram to test recognition of structures and can be considered a visual test. The significant differences in accretion time indicate that, although imagery is widely and heavily used during accretion, more extensive use of imagery can be induced by including visual illustrations.

The results of the present study provide evidence that imagery instructions are valuable for increasing learner interactions with instructional materials, and they may be especially important when spatial information must be learned. Some have argued that imagery instructions simply increase interest or motivation (Paivio, 1969). However, it seems that imagery instructions may be important for accurate learning of spatial or structural information. When visuals are presented, the spatial information is analyzed and processed. In the encoding process, parts of

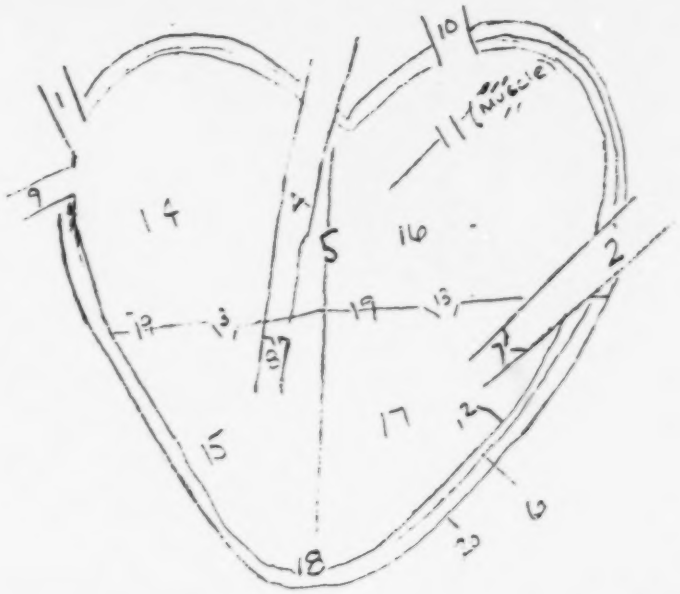
Directions: Draw a simple line picture of the heart and place the corresponding number (use the 20 parts in the list) where they would be located on the heart.



1. Superior Vena Cava
2. Aorta
3. Tricuspid Valve
4. Pulmonary Valve
5. Septum
6. Epicardium
7. Aortic Valve
8. Pulmonary Valve
9. Inferior Vena Cava
10. Pulmonary Artery
11. Myocardium
12. Endocardium
13. Mitral Valve
14. Right Auricle
15. Right Ventricle
16. Left Auricle
17. Left Auricle
18. Apex
19. Tendons
20. Pericardium

Figure 1. Drawing test of an uninstructed subject.

Directions: Draw a simple line picture of the heart and place the corresponding number (use the 20 parts in the list) where they would be located on the heart.



1. Superior Vena Cava
2. Aorta
3. Tricuspid Valve
4. Pulmonary Valve
5. Septum
6. Epicardium
7. Aortic Valve
8. Pulmonary Valve
9. Inferior Vena Cava
10. Pulmonary Artery
11. Myocardium
12. Endocardium
13. Mitral Valve
14. Right Auricle
15. Right Ventricle
16. Left Auricle
17. Left Auricle
18. Apex
19. Tendons
20. Pericardium

Figure 2. The drawing test of an instructed subject.

a visual illustration are given verbal labels and are concurrently analyzed by the non-verbal system regarding spatial and temporal relationships. Apparently, from the drawing scores of group TI, learners appear to benefit from using imagery.

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